ORDER **U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION

8260.47

5/26/98

SUBJ: BAROMETRIC VERTICAL NAVIGATION (VNAV) INSTRUMENT PROCEDURES DEVELOPMENT

1. PURPOSE. This order provides criteria for establishing instrument area navigation (RNAV) approach procedures using Barometric Vertical Navigation (VNAV) guidance meeting the standards of AC 20-129, Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the United States National Airspace System (NAS) and Alaska, or equivalent. Criteria in this document is used with lateral RNAV criteria contained in the applicable sections of Order 8260.40, Flight Management Systems (FMS) Instrument Procedures Development, and Order 8260.38, Civil Utilization of Global Positioning System (GPS). This criteria is also used in conjunction with appropriate provisions of Order 8260.3, United States Standard for Terminal Instrument Procedures (TERPS).

2. DISTRIBUTION. This order is distributed in Washington headquarters to the branch level of the Offices of System Safety; Aviation Policy and Plans; Air Traffic Systems Development; Aviation Research; Communications, Navigation, and Surveillance Systems; Airport Safety and Standards; and to Flight Standards, Air Traffic, and Airway Facilities Services; to the National Flight Procedures Office and National Airway Systems Engineering and Regulatory Standards and Compliance Divisions at the Mike Monroney Aeronautical Center; to the branch level in the regional Flight Standards, Air Traffic, Airway Facilities, and Airports Divisions; to all Flight Inspection Offices; International Flight Inspection Office; the Europe, Africa, and Middle East Area Office; Flight Standards District Offices; Airway Facilities Field Offices; to all addressees on special distribution lists ZVN-826, ZVS-827, and ZAT-423; and special Military and Public addressees.

3. DEFINITIONS.

a. Approach Surface Baseline (ASB). An imaginary horizontal line tangent to the earth at the threshold elevation extending to infinity. The ASB is aligned with the final approach course (FAC).

b. Barometric Vertical Navigation (BARO VNAV). A navigational system which presents computed vertical guidance to the pilot referenced to a specified Vertical Path Angle (VPA). The computer resolved vertical guidance is based on barometric altitude and is either computed as a geometric path between two waypoints or an angle from a single waypoint.

c. Decision Altitude (DA). A specified altitude in mean sea level in an approach with vertical guidance at which a missed approach must be initiated if the required visual reference to continue the approach has not been established.

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d. Decision Altitude (Height) (DA(H)). Decision altitude as defined in paragraph 3c and Height above touchdown zone (H). The height value is used for advisory reference only and does not necessarily reflect actual height above underlying terrain.

e. Final Approach Segment. The final approach segment for a VNAV approach begins at the final approach fix (FAF) and ends at the runway threshold. A waypoint shall be established at the FAF and runway threshold.

f. Height Above Threshold (HATh). For purposes of this order, HATh is defined as the height above the runway threshold elevation.

g. Obstacle Clearance Surface (OCS). An imaginary surface in the primary final approach obstacle clearance area being used for obstacle evaluation.

h. Vertical Path Angle (VPA). Used in connection with barometric VNAV operations to specify the vertical angle required on a segment.

i. Waypoint. A predetermined geographical position used for route definition specified in latitude/longitude. For purposes of this order, the terms waypoint and fix are synonymous.

j. Fix Displacement Tolerance. The rectangular area formed around and centered on the plotted position of the waypoint. This describes the region within which the aircraft could be placed when attempting to over fly the waypoint considering all error components. Its dimensions are plus-and-minus the alongtrack (ATRK) and crosstrack (XTRK) fix displacement tolerance values found in the applicable lateral RNAV criteria. For purposes of this order, the ATRK fix displacement tolerance value is 0.3 NM.

4. GENERAL CRITERIA.

a. Use of VNAV procedures developed in accordance with these criteria shall be limited to aircraft equipped with the following:

(1) A lateral navigation (LNAV) system meeting a two-dimensional accuracy requirement equal to or less than 0.3 NM (95% probability). The following systems meet this requirement:

(a) Global Positioning System (GPS) navigation equipment certified for approach operations under AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as VFR and IFR Supplemental Navigation System.

(b) Multi-sensor systems using inertial reference units (IRU) in combination with DME/DME or GPS certified under AC 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, for use in the U.S. NAS and Alaska.

(c) Required Navigation Performance (RNP) systems approved for RNP 0.3 NM operations or less.

(2) A VNAV system certified for approach operations under AC 20-129.

(3) A database containing the waypoints and associated VNAV information (altitudes and/or VPA) for the procedure to be flown that, once selected by the crew, is automatically loaded into the navigation system flight plan.

b. The final segment VPA is calculated from FAF altitude to the runway threshold elevation plus the threshold crossing height (TCH). VPA is computed as follows:

$$VPA = \arctan\left(\frac{total\,segment\,height\,loss\,in\,feet}{total\,segment\,length\,in\,feet}\right)$$

c. The optimum final segment VPA is 3°. The minimum final segment VPA is 2.75° and the maximum final segment VPA is 3.5°. Every attempt shall be made to accommodate the optimal VPA within ± 0.1°. Steps to accomplish this include changing the FAF altitude or moving the FAF location.

d. Procedures satisfying the criteria in this order shall be shown as a separate line of minima on the appropriate 8260 form. The minima shall be published as a DA(H) and shall be annotated "w/VNAV."

e. Chart the VPA and TCH of the VPA.

5. VNAV INSTRUMENT PROCEDURE DEVELOPMENT.

a. Determination of International Standard Atmosphere (ISA) Deviation.

(1) For the airport of interest, obtain the mean low temperature of the coldest month of the year for the last five years of data. Appendix 1 shows one method to accomplish this by using data from the National Weather Service (NWS) on the Internet.

(2) If the data is given in Fahrenheit, convert the temperature to Celsius using the following formula:

$T_C = \frac{5}{9}(T_F - 32)$**,** where T_C is degrees Celsius and T_F is degrees Fahrenheit.

(3) Convert the mean temperature found in paragraph 5a(2) into a deviation from ISA using the following equation:

$$T_{DEV} = T_C - \left(15 - \left(\frac{Elev}{500}\right)\right)$$

Where: T_{DEV} = temperature deviation from ISA in degrees C
T_C = mean temperature from step 2 above
Elev = airport elevation

(4) Round T_{DEV} to the next lower 5°C increment. Use this rounded T_{DEV} or -15°C, whichever is lower, and the VPA to find the VNAV OCS slope from table 1 of appendix 2.

b. VNAV OCS Application.

(1) The VNAV OCS underlies the final segment Obstacle Clearance Area (OCA) and begins at a point on the ASB corresponding to the location of the 250' HATh point. Figure 1 of appendix 2 shows the basic construction of the VNAV OCS. (All examples are based on a VPA of 3.0°, a T_{DEV} of -30°C, TCH of 50' and a FAF located at the 1,500' HATh point.) In figure 1 of appendix 2, the OCS begins at point A, a distance of 3,816.23' from the threshold. The beginning point of the OCS is found using the following formula:

$$D_{250' HATh} = (250' - TCH) / \tan(VPA)$$
$$D_{250' HATh} = (250'-50')/\tan(3°) = 3{,}816.23'$$

where $D_{250' HATh}$ is the distance to the 250' HATh point along the ASB.

(2) The OCS is drawn from point A in appendix 2, figure 1 to the FAF plus 0.3 NM distance at the slope determined in paragraph 5a(4). This is shown as point B in appendix 2, figure 1.

(3) The lateral dimensions of the VNAV OCS, including secondary areas, are equal to the final segment OCA dimensions as taken from Order 8260.38 or Order 8260.40.

c. Determination of DA. The procedure DA shall be the higher of two separate evaluations.

(1) The first evaluation is conducted in the final approach segment from the threshold to the 250' HATh point. This area is shown as section 1 in appendix 2, figure 2. The result of this evaluation is DA_1.

(a) Primary area. Apply a 250' required obstruction clearance (ROC) value to the highest obstacle in the primary area of section 1.

(b) Secondary area. Apply a 250' ROC at the edge of the primary area decreasing to 0' ROC at the edge of the secondary area.

(2) The second evaluation will make use of the VNAV OCS. As figure 2 shows, the appropriate OCS depending on VPA and temperature has been drawn as described in paragraph 5b(2). This area is shown as section 2 in appendix 2, figure 2. If no obstacle penetrates the OCS, DA_2 is equal to DA_1.

(a) Section 2 secondary area obstacles. The secondary area has a slope of 7:1 measured perpendicular to segment centerline. To evaluate an obstacle in the secondary area, determine the height of an equivalent obstacle on the edge of the primary area. Then evaluate the equivalent obstacle relative to the VNAV OCS as described in paragraph 5b. Example - a 9,839' MSL obstacle is located in the secondary 2,700' from the edge of the primary area. The height of an equivalent obstacle is found as follows:

7:1 slope to edge of primary area: $\frac{2{,}700'}{7} = 385.7'$

Height of equivalent obstacle: 9,839.0' - 385.7' = 9,453.3'.

(b) If an obstacle penetrates the OCS, the following options are available:

1. Remove the obstacle.

2. The VPA can be increased and the steps in paragraphs 5c(1) and (2) repeated. VPA shall not exceed 3.5°.

3. An adjustment can be made to DA_2 by adding the ROC from table 2 of appendix 2 to the obstacle height. Enter table 2 of appendix 2 with the T_{DEV} from paragraph 5a(4) and the height of the obstacle above threshold elevation to determine the ROC. Add this ROC value to the MSL height of the highest penetrating obstacle and the result is the new DA_2.

4. The threshold can be displaced and steps in paragraphs 5c(1) and (2) repeated.

(3) The DA for the approach shall be the higher of DA_1 or DA_2. Standard rounding to the next higher 20' increment applies. In no case will the approach DA result in a HATh lower than 250'.

d. Visual Segment Evaluation. In order to publish a VNAV DA(H), the aircraft must be able to be visually maneuvered from the DA to the runway without regard to avoiding obstacles. This area along the approach is called the visual segment. The visual segment is aligned with the runway centerline extended. The visual segment begins at the threshold and extends to a distance equal to the DA point plus 0.3 NM. Figure 3 of appendix 2 depicts the visual segment. The angle of the visual segment surface is $(\frac{2}{3}\text{VPA})$. For example, for a VPA of 3°, the visual segment slope is 2°. The half width of the visual surface is (0.2d)+200' where d is the distance from threshold in feet. No penetrations of this surface are allowed.

e. Approach Visibility Determination. If the FAC is within 3° of runway bearing, the minimum visibility before light credit shall be the distance along the ASB from the threshold to the DA point or 3/4 mile, whichever is greater. If the FAC is offset more than 3° from runway bearing (up to a maximum offset of 5°), the minimum visibility before light credit shall be the distance along the ASB from the threshold to the DA point or 1 mile, whichever is greater. Use nonprecision guidance from Order 8260.3, table 9 for applying light credit reductions. In no case shall the visibility be less than 1/2 mile or 2400 runway visual range (RVR).

f. Missed Approach Construction. With the following exceptions, apply missed approach criteria contained in FAA Order 8260.38.

(1) The missed approach segment begins at a point on the FAC equal to the distance to the DA point minus the height loss adjustment. The height loss adjustment distance is $[50'/\tan(\text{VPA})]$. A navigation system displacement area is drawn around this point with width equal to the width of the OCA and length equal to plus/minus 0.3 NM. See figures 4 and 5 of appendix 2.

(2) The missed approach area starts at the earliest point of the displacement area and expands uniformly to a width of 6 NM each side of course line at a point 15 NM (measured along flight-track). When positive course guidance is provided, a secondary area reduction is permitted.

(3) The 40:1 surface shall start from an altitude equal to the (DA - ROC - adjustments -50'). The 40:1 surface begins at the latest point of the displacement area.

(4) No turns are permitted prior to the runway threshold waypoint (RWP).

g. Excessive Length of Final Adjustment. Not applicable for BARO VNAV procedures.

h. Remote Altimeter Setting. BARO VNAV procedures are not authorized with a remote altimeter setting. If 24-hour weather reporting is not available at the airport, use standard note "When XYZ altimeter setting not received, procedure NA."

i. Runway Alignment. Whenever possible, the FAC shall be aligned with the runway. Where this is not possible, the FAC shall be within 5° of the runway bearing aligned to the runway threshold. For a FAC offset more than 3°, annotate the procedure as follows: "Final approach course offset by X.Y degrees."

j. Threshold Crossing Height (TCH). Apply guidance in Order 8260.3, table 18A.

k. Visual Descent Point (VDP). Do not publish a VDP on a VNAV only approach. If a VNAV approach is combined with a LNAV only approach on the 8260 form and a VDP is charted for the LNAV portion, annotate the VDP as applying to the LNAV only, e.g. "VDP*","*LNAV only."

l. Temperature Limitation. Each BARO VNAV approach shall include a temperature limitation below which the VNAV portion of the procedure is not authorized for use.

(1) The temperature limitation is computed as follows:

$$T_{LIM,C} = T_{DEV} + \left(15 - \left(\frac{Elev}{500}\right)\right)$$

where: T_{DEV} = ISA deviation from paragraph 5a(4) used to determine the VNAV OCS.

Elev = airport elevation
$T_{LIM,C}$ = temperature limitation, °C.

(2) Compute $T_{LIM,F} = \left(\frac{9}{5} Tc\right) + 32$

where: $T_{LIM,F}$ = temperature limitation, °F.

(3) Annotate the VNAV procedure in the plan view with an identifying mark such as an asterisk and chart the temperature limitations. Round $T_{LIM,C}$ and $T_{LIM,F}$ to the next higher whole degree. Example:

"*VNAV minima not authorized below -1°C (31°F)."

6. INFORMATION UPDATE. Any deficiencies found, clarification needed, or improvements to be suggested regarding the content of this order, shall be forwarded for consideration to:

DOT/FAA
ATTN: Flight Procedure Standards Branch, AFS-420
P.O. Box 25082
Oklahoma City, OK 73125

a. Your Assistance is Welcome. FAA Form 1320-19, Directive Feedback Information, is included at the end of this order for your convenience.

b. Use the "Other Comments" block of this form to provide a complete explanation of why the suggested change is necessary.

Thomas E. Stuckey
Acting Director, Flight Standards Service

National Weather Service Data on the Internet to Determine Mean Temperature

One method to determine the mean temperature of the coldest month of the year for the airport of interest is by using data from the National Weather Service (NWS) on the Internet. As of the writing of this order, the Internet address and applicable elections are shown below:

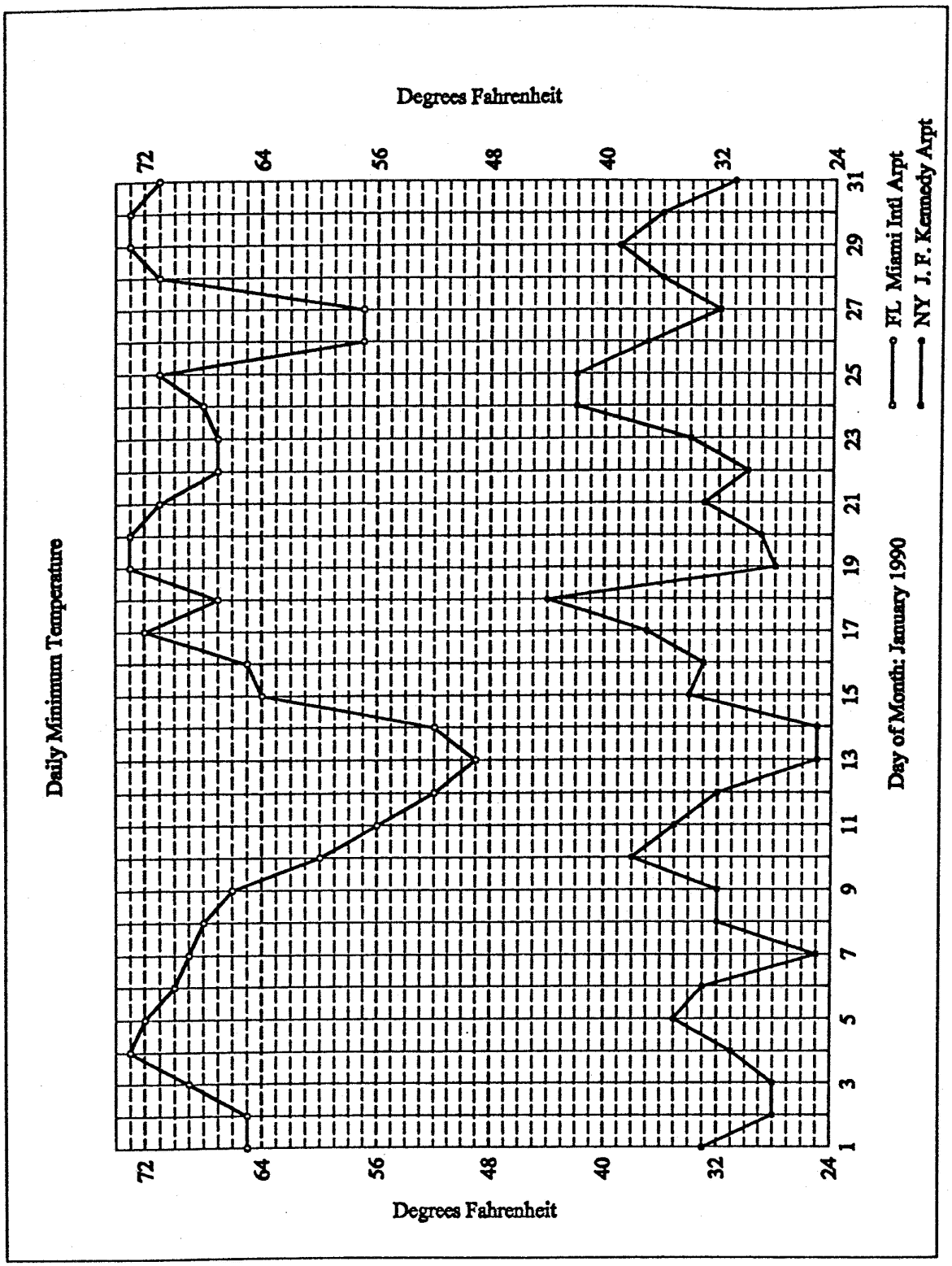
(1) Internet address: www.ncdc.noaa.gov/onlineprod/drought/xmgr.html

(2) This should take you to Climate Visualization (CLIMVIS) page.

(3) Under Graphics Choices, select a **Time Series** from the **National Weather Service Summary of the Day**. Select **Daily Minimum Temperature** for the airport of interest for the coldest month. Figure 1 shows an example for MIA and JFK for January 1990. Repeat this process for the five most recent years of data.

(4) Average the monthly minimum temperature values for five years of data to find the mean low temperature.

Figure 1. DAILY MINIMUM TEMPERATURE



APPENDIX 2. FIGURES AND TABLES

FIGURES **Page No.**

TABLES

Figure 1. VNAV FINAL APPROACH SEGMENT OCS

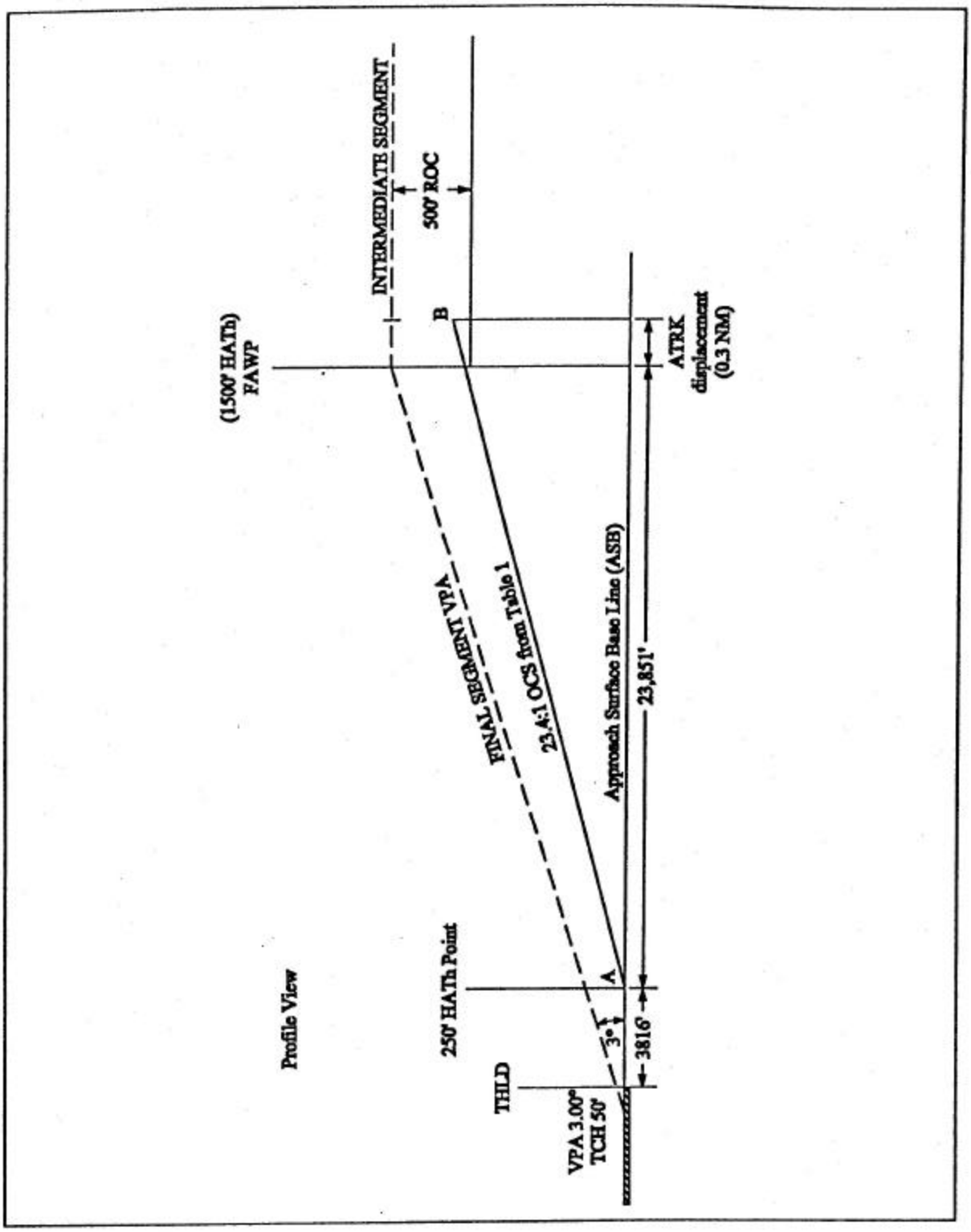


Figure 2. DETERMINATION OF DECISION ALTITUDE (DA)

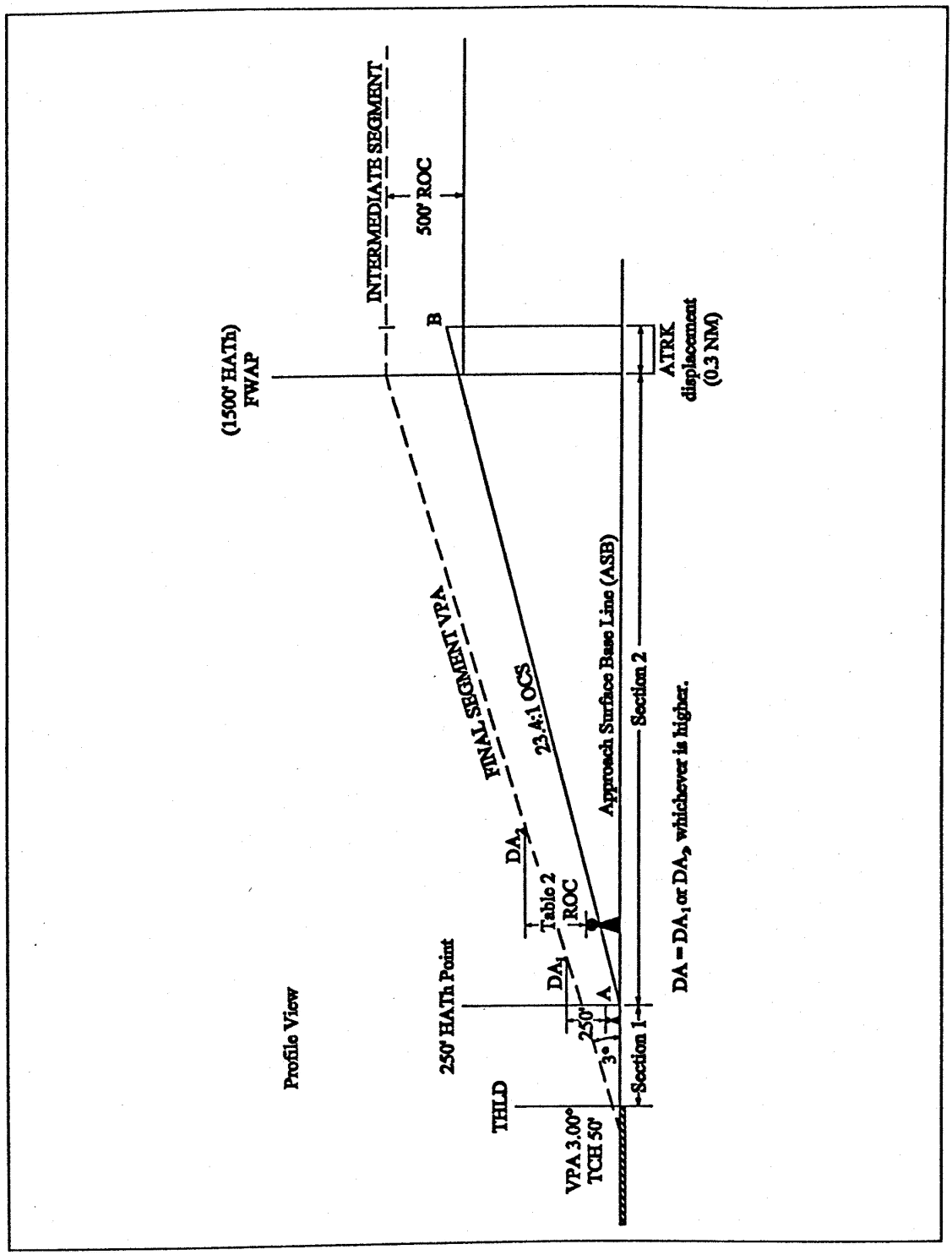


Figure 3. VISUAL SEGMENT EVALUATION

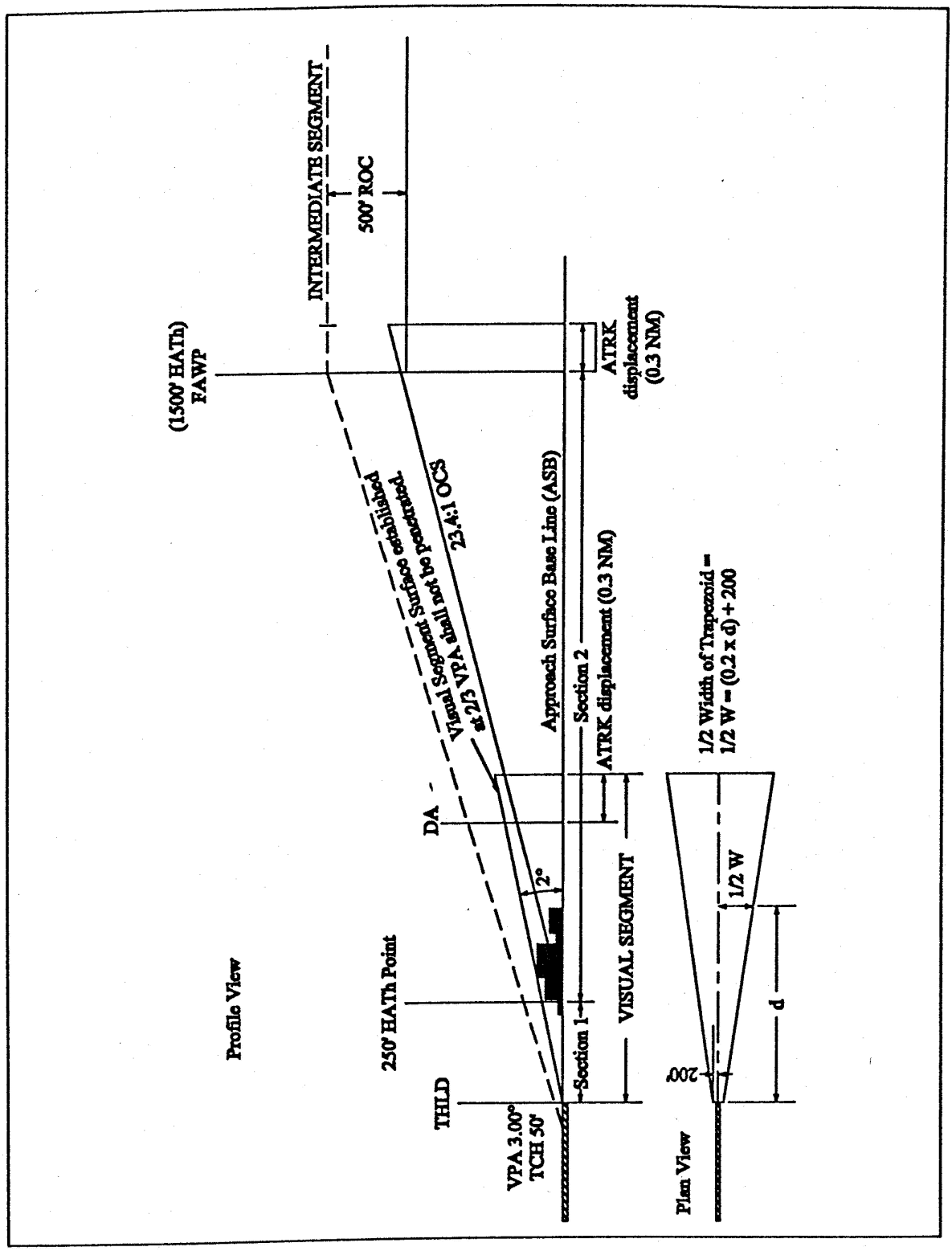


Figure 4. VNAV MISSED APPROACH SEGMENT (PROFILE VIEW)

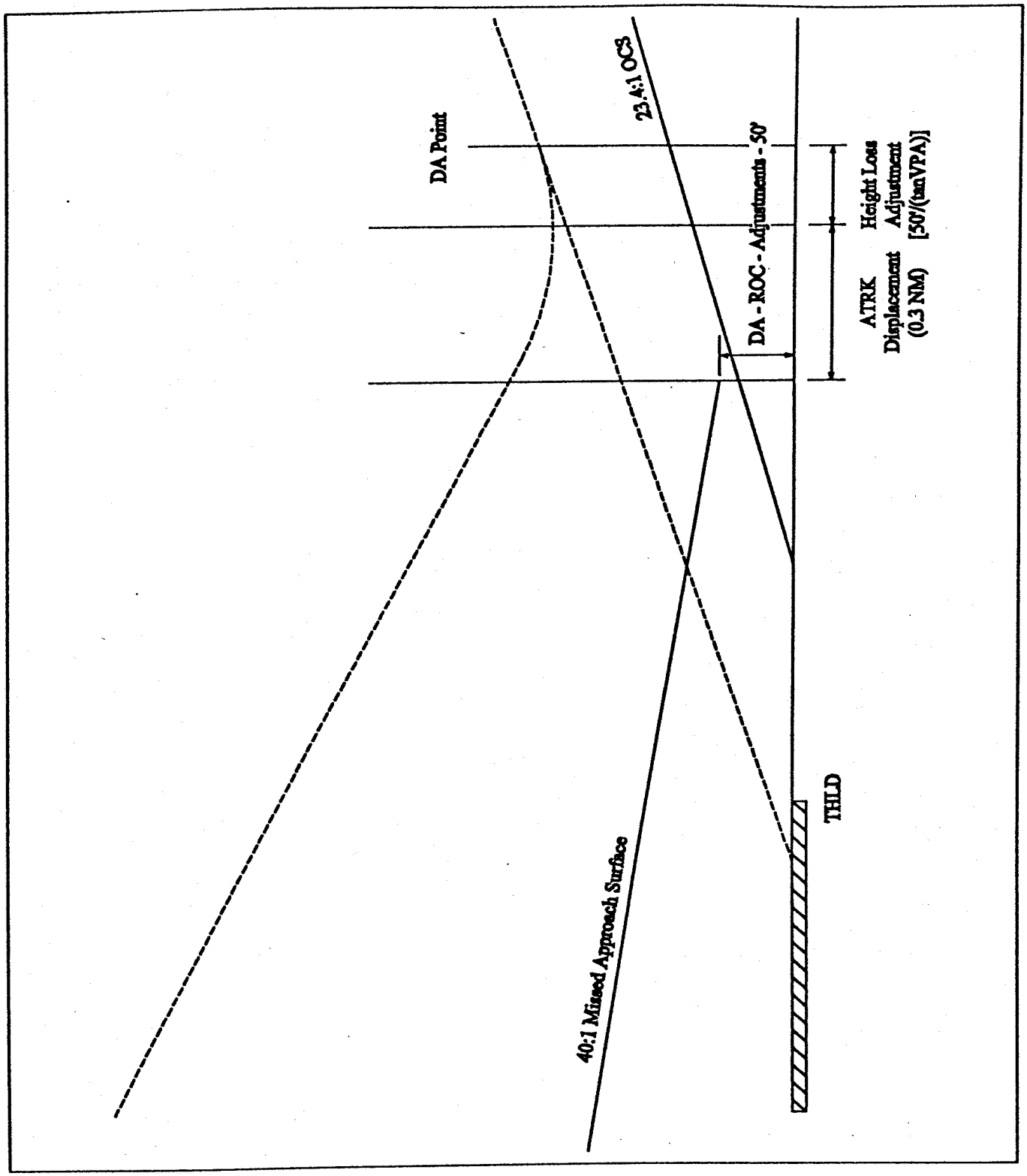


Figure 5. VNAV MISSED APPROACH SEGMENT
(Plan View)

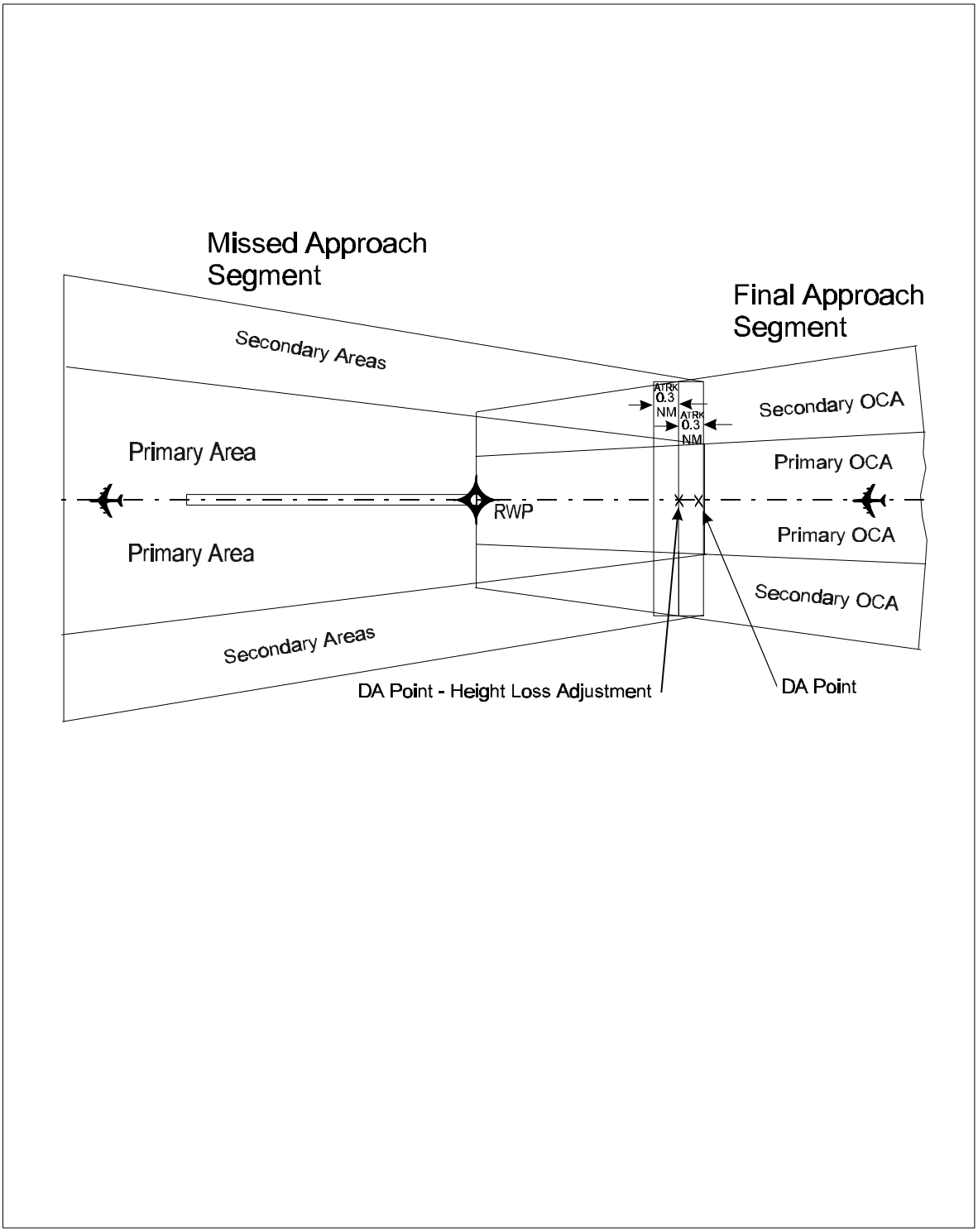


TABLE 1.
BAROMETRIC VNAV OBSTACLE CLEARANCE SURFACE (OCS) SLOPE
VS.
ISA DEVIATION AND VERTICAL PATH ANGLE

	Vertical Path Angle (deg.)											
ISA (C) DEV	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
-10	23.2	22.4	21.7	21.0	20.4	19.8	19.3	18.8	18.3	17.8	17.4	17.0
-15	23.8	23.0	22.2	21.6	20.9	20.3	19.8	19.3	18.8	18.3	17.9	17.5
-20	24.4	23.6	22.9	22.2	21.5	20.9	20.3	19.8	19.3	18.8	18.4	18.0
-25	25.1	24.3	23.5	22.8	22.1	21.5	20.9	20.4	19.9	19.4	18.9	18.5
-30	25.8	25.0	24.2	23.4	22.8	22.1	21.5	21.0	20.5	20.0	19.5	19.1
-35	26.6	25.7	24.9	24.1	23.4	22.8	22.2	21.6	21.1	20.6	20.1	19.6
-40	27.4	26.5	25.7	24.9	24.2	23.5	22.9	22.3	21.7	21.2	20.7	20.3
-45	28.2	27.3	26.5	25.7	24.9	24.2	23.6	23.0	22.4	21.9	21.4	20.9
-50	29.1	28.2	27.3	26.5	25.8	25.0	24.4	23.8	23.2	22.6	22.1	21.6

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TABLE 2.
BAROMETRIC VNAV REQUIRED OBSTACLE CLEARANCE (ROC, FEET)

Temp Deviation (deg C) below ISA at station	Altitude above station (ft)							
	250	500	750	1000	1250	1500	1750	2000
10	250	250	250	250	250	250	250	250
15	250	250	250	250	250	250	250	250
20	250	250	250	250	250	250	250	250
25	250	250	250	250	250	250	250	275
30	250	250	250	250	250	250	275	310
35	250	250	250	250	250	270	305	345
40	250	250	250	250	255	295	340	380
45	250	250	250	250	280	325	370	410
50	250	250	250	260	305	355	400	445
55	250	250	250	280	330	380	430	480
60	250	250	270	300	355	410	460	515

U.S. Department
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Directive Feedback Information

Please submit any written comments or recommendations for improving this directive, or suggest new items or subjects to be added to it. Also, if you find an error, please tell us about it.

Subject: Order 8260.47, Barometric Vertical Navigation (VNAV) Instrument Procedures Development

To: Flight Procedure Standards Branch, AFS-420
P.O. Box 25082
Oklahoma City, OK 73125

(Please check all appropriate line items)

☐ An error (procedural or typographical) has been noted in paragraph _____ on page _____

☐ Recommend paragraph _____ on page _____ be changed as follows:
(*attach separate sheet if necessary*)

☐ In a future change to this directive, please include coverage on the following subject:
(*briefly describe what you want added*):

☐ Other comments:

☐ I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____

FTS Telephone Number: _____ Routing Symbol: _____

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